MARK IV MONORAIL

2 Four Generations of Monorail Systems

DISNEYLAND opened in 1955 with an exposition of transportation systems from double-decker buses to riverboats. Already a mini-city in transportation activity, DISNEYLAND inaugurated the first daily monorail service in 1959. The design and development of the monorail system reflected Walt Disney's personal commitment to not only build an attraction, but more importantly, to provide a transportation system for the future.

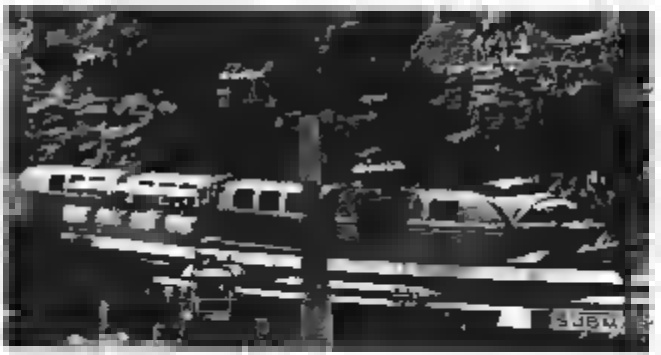
In 1961, with increasing transportation needs, the monorail system was expanded to include the Disneyland Hotel. At the same time, three new MARK II trains were introduced, each having four cars. Operating now on 2.5 miles of beamway, with two stations, the MARK II was the first monorail to run adjacent to a major highway and cross city streets.

As the demand for additional capacity grew, so did the monorail system. In 1969, four new MARK III five-car monorails were unveiled, demonstrating Disney's true dedication to stay at the forefront of technology.

Then with the opening in 1971 of the WALT DISNEY WORLD Destination Resort in Florida, the Disney organization revealed a new monorail system as the primary transportation link between the resort hotels, main parking area, and the Magic Kingdom. The economic viability of the entire WALT DISNEY WORLD Resort Area is hinged on the performance and reliability of the MARK IV Monorail System. This expression of confidence in the MARK IV monorail was made possible through the many years of experience Disney accumulated since inaugurating the first MARK I in 1959. The MARK IV Monorail carries over 25 million passengers a year with a sustained reliability record of over 99.9%.

In 1982, Disney's new Experimental Prototype Community of Tomorrow — Epcot Center — was linked to the other resort areas by an eight-mile extension of the existing MARK IV Monorail System. The 14 miles of beamway now in Florida make the MARK IV Monorail System one of the only privately funded profitable regional transit systems in the country. As a part of the future development of Epcot Center, WED Transportation Systems will develop the transportation systems and technologies to be showcased to the public in a continuing effort to provide clean, efficient transportation to cities throughout the world. WED Transportation Systems represents two decades of research, development, construction, testing, and operation of transportation systems — systems that not only provide solutions to Walt Disney Productions needs, but also provide economical solutions to the transportation needs of today's cities and airports.

MARK I - 1959



MARK II - 1961

MARK III - 1969

MARK IV - 1971

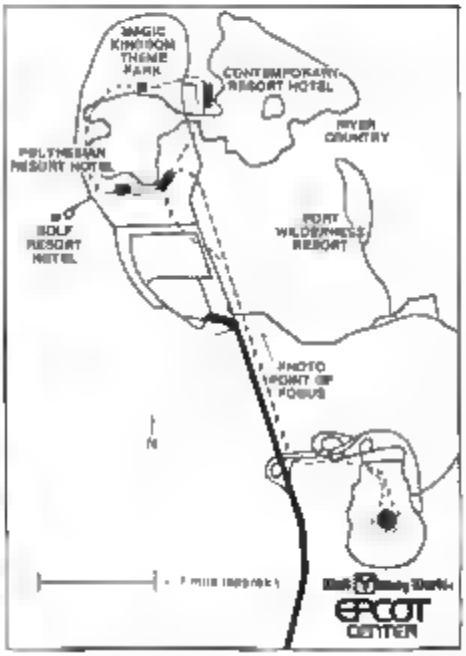
3 MARK IV Monorail System Overview

The MARK IV Monorail System at the WALT DISNEY WORLD Vacation Kingdom is one of the most advanced time-proven technologies in operation anywhere in the world. In 10 years of daily passenger service, the 10 MARK IV trains have logged over 5 million miles and carried some 250 million passengers. The silent-running, all-electric trains combine luxury with outstanding achievements in engineering and operate at one-tenth (477 Btu's per passenger mile) of the energy required for commuting automobiles.

Operating on a 26 inch wide beam the WALT DISNEY WORLD Monorail represents one of the most cost-effective fixed guideway transit systems in the world. It's slender profile is extremely stingy in its use of construction materials when compared with other conventional elevated systems. Tapered precast concrete columns support prestressed post-tensioned sections of beamway up to 60 feet above the terrain for spans up to 110 feet. Passing directly through the fourth floor of the Contemporary Resort Hotel the monorail can serve 10,000 seated passengers an hour. Stations serving main transportation hubs utilize the 'through loading' capability of the MARK IV's paired doors on alternate sides of the train. This type of loading/off-loading can reduce station dwell times by 50% when compared with a single-sided operation. A transfer point at the main transportation center serves as the link to the new eight-mile extension serving Epcot Center. Seating is provided for all passengers and the traditional 'crush loading' is an experience that has been eliminated by the operational configuration of the train. Provisions for handicapped persons are available on the MARK IV series monorail.

Advanced designs and easy-access maintenance have proven to be key factors in the MARK IV's 99.9% operational readiness record accumulated over the past 10 years. With total operating costs remaining below $.05 per passenger mile during 1981, the WALT DISNEY WORLD MARK IV Monorail System is unsurpassed in transportation economy and reliability.

The 14.7-mile MARK IV Monorail system at the Walt Disney World Vacation Kingdom



4 Stations

Five monorail stations serve the WALT DISNEY WORLD resort hotels, visitor parking lots, the theme park and Epcot Center areas. Three stations are above grade and two stations are on-grade. All five stations are designed for dual beam operation, and the high volume traffic of the theme park and transportation center stations utilize the unique through-loading capability of the MARK IV trains. With trains arriving from both directions every two minutes, station attendants stage passengers in chutes for quick loading. The loading chutes permit car and seat selection prior to train arrival and reduce loading confusion once the train is in the station. Inbound passengers arriving on the train exit from the opposite side of the train and are routed down an exit ramp without intermingling with outbound passengers.

Main Transportation Center Station at Grade Level

At-Grade Station

5 Trains

The five- and six-car MARK IV trains at the WALT DISNEY WORLD Resort Complex incorporate the latest proven designs and technology derived from over 20 years of daily monorail operating experience. Each six-car monorail is 201 feet long, weighs 50 tons empty, and carries 244 passengers in total air-conditioned comfort. Each train has twelve 18-ply pneumatic load tires to provide propulsion and braking from eight 100 hp, 600-volt, DC electric motors/dynamos. There is also an 18-inch mechanical disk brake on each load tire, but the mechanical system generally accounts for less than one-fourth of the braking required in normal operation.

Foam filled side tires in lateral contact with the beamway guide the monorail chassis. The coaches are suspended over each load tire on air bag cushions which are automatically inflated or deflated to correct for varying load conditions.

Passengers board through five air-actuated doors on either side of the train. Disabled passengers may be accommodated through a special wide-access door on each train. Automatic sliding doors are also available.

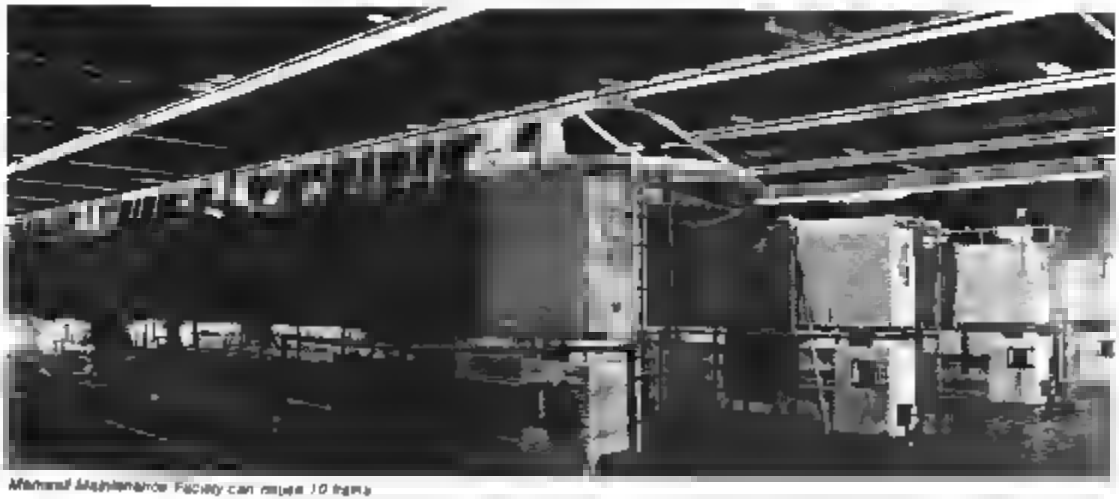
Monorail passengers

Six-car Mark IV can carry 244 seated passengers

Electric power for the monorail is picked up by eight carbon collectors in contact with a 600-volt buss bar below the train. Safety interlocks in the driver's console preclude operation of a train without all doors secured. The operator can select one of four forward speed settings, neutral or three braking positions. Acceleration and deceleration is accomplished from the operator's selected setting by automatically stepping through 15 power increments or 10 braking selections. Maximum acceleration is 3.0 fps^2, and deceleration is 5.0 fps^2. MARK IV Monorail trains can be operated in either direction.

Maintenance activities are performed in the monorail "roundhouse" where each train is given a daily check. Side compartments give easy access to most components of the MARK IV train, and permit visual inspection of the train's main support systems in a matter of minutes. In operation for over 10 years, the MARK IV trains have maintained an impressive reliability record of 99.9% with a total maintenance staff of less than 30 people covering the year-round operations.

Easy access maintenance



Monorail Maintenance Facility can house 10 trains

7 Beamway

Heights to 60 feet

The nearly 75 000 feet of beamway at the WALT DISNEY WORLD Resort Complex represents the state of the art in structural designs and material technology. The Disney design features long-span prestressed post-tensioned beams with curved haunches, precast columns and cast-in-place substructure — a combination that creates a technically exciting and highly functional structure. Close attention to tolerances for riding comfort, smooth geometry, and few disruptive discontinuities provide an aesthetically pleasing structure totally compatible with its surroundings. Tapered precast concrete columns support the monorail beamway to a maximum height of 60 feet. The 26-inch-wide prestressed girders are typically 90 to 110 feet in length, midspan depths are 48 inches and at the ends of parabolic haunches

26-inch-wide beamway

Spans to 110 feet

they are 60 inches in depth. The beams were cast with a hollow center core to keep weights under 50 tons. Approximately half of the beams have some combination of vertical and horizontal curvatures and variable super elevation. Accurate prestressing insures zero camber for the guideway girders. Once in place, post-tensioning allows final alignment of segments of the beamway to reduce any remaining discontinuities.

The beamway provides electrical power to the trains through a 600-volt DC buss bar affixed to the lower sides of each beam. The buss bar is fed from separate power rectifier stations along the beamway.

Switching is accomplished by two types of switches. Maintenance area and off-line switching uses a pivot segment of beam. On-line switching incorporates a newly developed "beam replacement" switch which allows high speed operations through the switch.

Rectifier Station Equipment

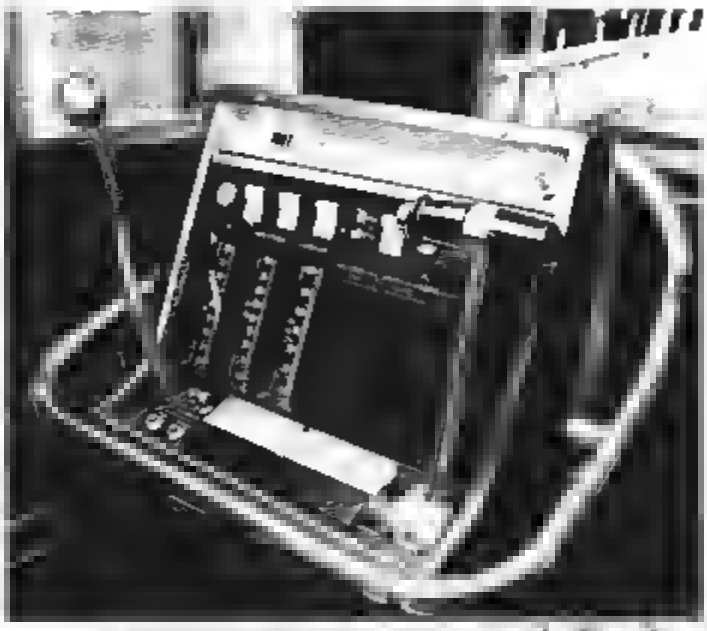
Rectifier Support below beamway

New Maintenance Switch-Beam replacement type

Buss bar and collector shoe

9 Control System

Train Subsystem Monitor Panel



Train Operator Console

Two separate control systems monitor train separation. The first and most important is the operator's visual surveillance of the beamway. In addition, a proximity warning system automatically alerts the operator to proceed with caution when trains approach minimum headways. Should an operator inadvertently close within an unsafe distance of another train, a backup electronic detection system will automatically drop power from the drive motors and apply braking until the train is completely stopped.

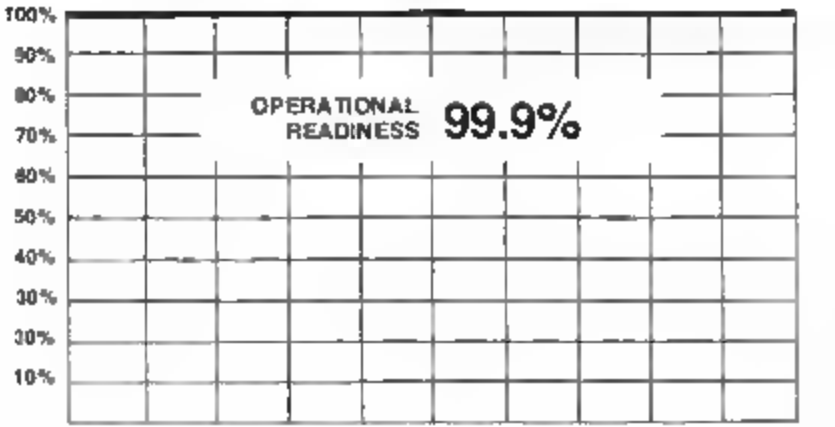
Communication with each train operator is maintained via radio. Train-to-train, train-to-maintenance and train-to-station communication allows additional control and safety should all other systems be inoperative. The operator can announce upcoming stations and other operating information to passengers over the train's onboard public address system.

Speed is controlled by the operator's selection of one of several preset speeds. The electric traction motors are automatically stepped through power increments until the selected speed is reached. Braking rates are input by operator controls to provide smooth deceleration using both dynamic and mechanical braking systems.

Safety interlocks prevent any train motion without all necessary doors and other devices positioned for travel.

Station attendant in Radio Contact with Train Operator

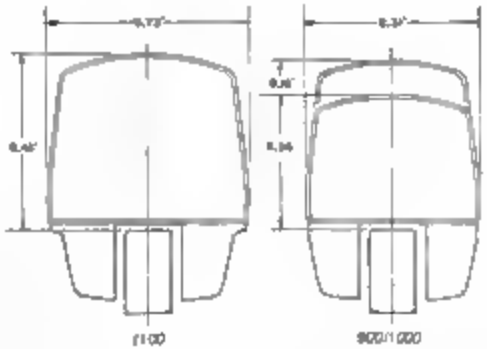
10 Operations



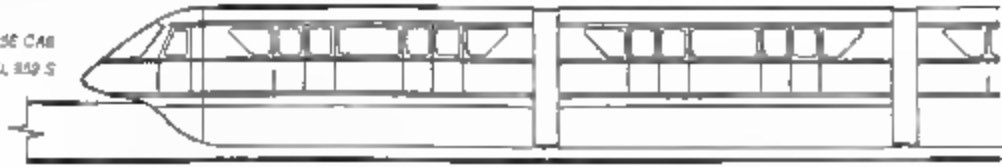
The WALT DISNEY WORLD MARK IV Monorail System is the most heavily traveled passenger monorail in the world. With over five million train-miles accumulated since 1971, the MARK IV Monorail has transported an average of 70 thousand passengers a day, 365 days a year. This service level has been maintained with a system reliability of 99.9% and operating costs below $.08 per passenger mile in 1981.

Station attendants stage passengers for boarding prior to train arrival to insure minimal delays. Train operators provide enroute briefings to passengers on operating schedules, upcoming stops, exiting instructions and other connecting transportation information.

Train separation is maintained by operator surveillance and train-to-train communications. However, an automatic electronic separation system exists as a backup to insure maximum safe distances are maintained. The simplified operator's console with visual monitors guarding 33 operating factors, allow operator training to be performed in a few weeks. Interlock systems on each train prevent inadvertent operation when a potential malfunction is detected.



TYPICAL MODULAR CAR DESIGNS

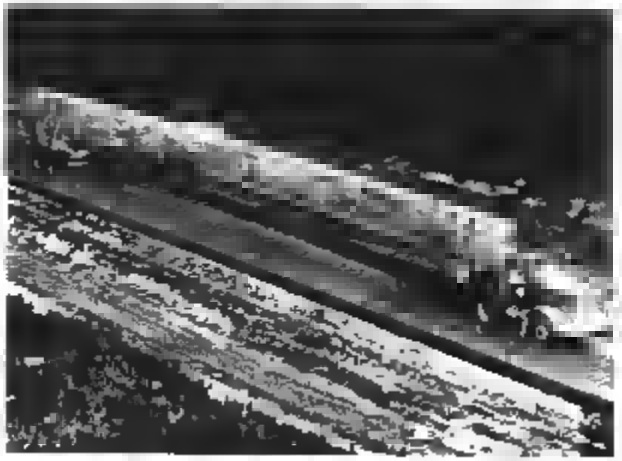


REMOTE CASTING YARD

Beams and columns are all precast in a remote casting yard designed for assembly line production of the major monorail guideway elements. Carefully controlled conditions insure that tolerances are maintained and material wastes are minimal. The concrete beams and piers are cured at this remote facility before installation.

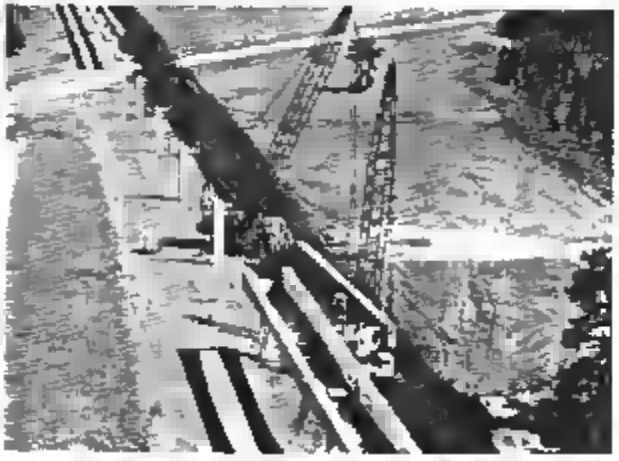
MONORAIL BEAM TRANSPORTER

Completed monorail beams and columns are transported to the construction site by "hook-and-ladder" type transporters. These vehicles can operate over normal highway routes and minimize disruption caused by traditional formwork and concrete pouring in congested construction areas.



MONORAIL BEAM PLACEMENT

Guideway elements delivered by the transporters are quickly lifted into place by cranes. Final adjustments and alignment checks are made after post-tensioning of six-member groups.

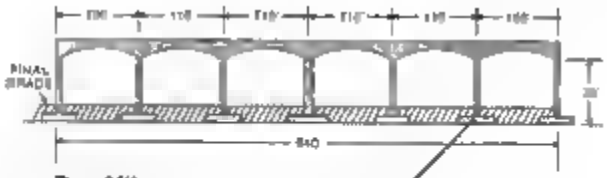


GUIDEWAY COMPARISON*

MONORAIL VERSUS ELEVATED RAIL

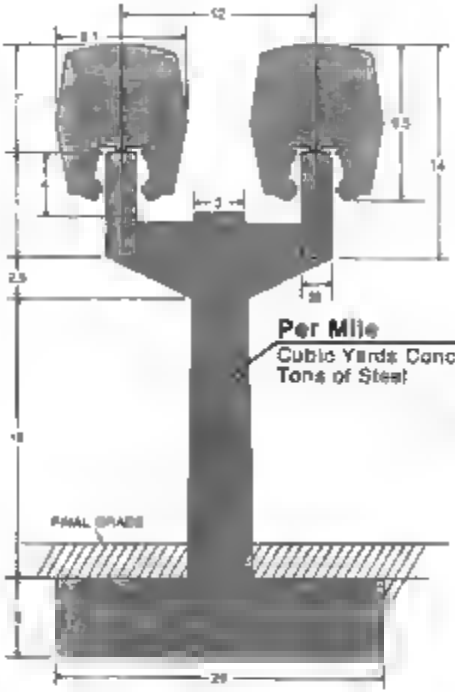
The slender monorail beamway is unique in that it serves as the guideway's structural member and vehicle running surface. Concrete consumption typically is one-fourth that used in elevated rail systems. Reinforcing steel needed per mile of construction is generally less than one-half that of elevated rail systems. These material advantages combined with longer spans requiring fewer column placements per mile make the monorail beamway one of the most cost-effective, high capacity guideways in existence.

Monorail | **Elevated Rail**



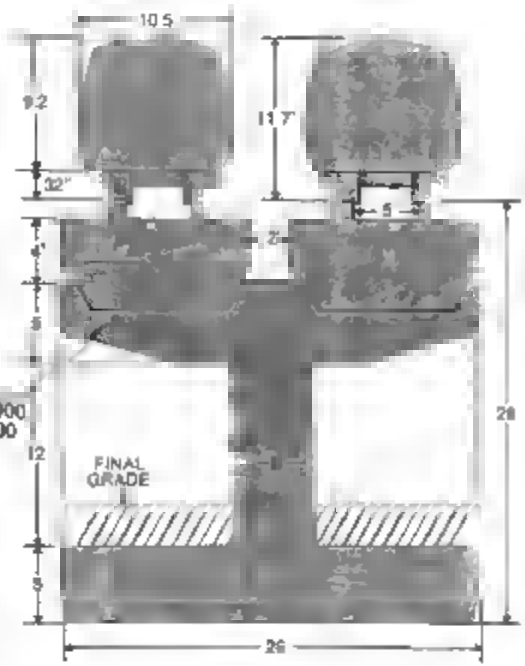
Per Mile
Pier Placements & Foundations 50

Per Mile
Pier Placements & Foundations 75



Per Mile

Cubic Yards Concrete	5,800
Tons of Steel	1,200



Per Mile

Cubic Yards Concrete	28,000
Tons of Steel	2,900

* Based on actual monorail construction at WALT DISNEY WORLD and elevated rapid rail construction in the United States

13 Community Applications

Walt Disney monorail systems offer significant benefits to communities seeking modern solutions to the problems of traffic congestion, air pollution, and fuel conservation. Operating over existing freeway medians, versions of the MARK IV Monorail can easily eliminate tens-of-thousands of would-be drivers and place them in the quiet, air-conditioned comfort of a swiftly moving electric monorail train. Commuting by monorail will not only alleviate traffic congestion, but will also greatly reduce the release of automotive pollutants into the air. The per passenger energy efficiency of the MARK IV Monorail is over 10 times that of the automobile, and significant fuel savings can result as rising fuel costs become a more important consideration.

Benefits of the monorail system are more than monetary. Because the unique elevated beamway needs less horizontal clearance than traditional road and rail systems, the acquisition of additional right-of-ways is seldom needed. Valuable land representing the City's tax base is not consumed by wide strips of asphalt or concrete. Likewise, the maintenance costs of a narrow concrete monorail beam are significantly less on a per mile basis than that of freeway or subway track. Public transportation budgets today need these factors working for the taxpayers and the commuter patrons.

WED Transportation Systems now offers its Modular Car Design to accommodate the specific needs of a particular commuter system. The Modular Car Design permits an economical configuration of a monorail train tailored to the performance requirements of the operator without sacrificing the time-proven control and propulsion systems. The foundation of this design is a basic monorail chassis to which a separate body unit is attached. Flexibility in the body design is possible by utilizing three subcomponents: a midsection and two end sections. Interior seating and sliding doors can also be arranged in various configurations. Overall, the Modular Car Design provides a very flexible approach to adapting the basic MARK IV Monorail for public use, while maintaining economies in production and proven technology.

High speed monorails offer many other advantages to communities seeking innovative ways of solving the problem of public transportation. The environmental and economic benefits associated with the WALT DISNEY family of monorails truly make them a transportation system of the future — here today.

14 Monorail System Summary

SYSTEM PERFORMANCE

CAPACITY: 10 000 per hour

MAXIMUM WAIT TIME 2 minutes

HEADWAYS: 90 seconds

DWELL TIMES. 45 to 90 seconds

RELIABILITY

TOTAL SYBTEM. 99 9%

TRAINS (10)* 99 9%
(Oct. 80 - Sept 81)

1981 OPERATING PROFILE

SYSTEM OPERATING HOURS 5 886

SYSTEM DOWNTIME.

Loss of Power	1 hrs 10 minutes
Weather	0 hrs. 7 minutes
Total	1 hrs. 17 minutes

TRAIN OPERATING HOURS 40 183

TRAIN DOWNTIME (10 TRAINS):

Mechanical	5 hrs 56 minutes
Electrical	2 hrs. 24 minutes
Total	8 hrs. 20 minutes

TRAIN PERFORMANCE

GRADE 6%

ACCELERATION 3 0 ft/sec²

DECELERATION* 5 0 ft/sec²

DIRECTION Reversible

ENERGY CONSUMPTION

TOTAL SYSTEM PER YEAR	5 511,200 KWH
PER TRAIN OPERATING HOUR	137 KWH
PER TRAIN MILE*	11 52 KWH
PER PASSENGER MILE	14 KWH
PER SEAT MILE.	.05 KWH

TRAIN DESIGN

LENGTH* 5 cars — 171 feet
6 cars — 201 feet

WIDTH 8 10

HEIGHT 11 7

OPERATING ENVELOPE. 10' x 12'4"

WEIGHT (lbs.)

	Empty	Gross
5 cars	92 000	122,600
6 cars	108 500	145 100

BODY TYPE: Honeycomb bonded aluminum panels

ENVIRONMENTALS. Heating and Air-conditioning

GUIDANCE Saddle-type monorail

COMMUNICATIONS Two-way radio. PA with taped narration to passengers

HANDICAP Wheelchair lis-downs

PROPULSION AND BRAKING

MOTORS, 600 VDC 100 HP (8 per train)

CONTROLS. Manual, synchronized drive cam controlled

BRAKING Dynamic and hydraulic disc

POWER COLLECTION Replaceable carbon shoes (8 per train)

BEAMWAY

LENGTH: 14 7 miles

TYPE Elevated, prestressed and post-tensioned concrete

COLUMNS Tapered concrete up to 65 feet

SPANS 40' to 110

RADII* Horizontal — 500 feet
Vertical — 1000 fset

SWITCHES

TYPE Pivot and beam replacement

NUMBER 7 pivot 2-beam replacemant

LOCK-TO-LOCK 30 seconds

STATIONS

NUMBER 5

TYPE* On-line

BOARDING. Through loading by designated destination

DWELL Express 45 seconds
Local 90 seconds

SAFETY

TRAIN SEPARATION: A manual system with automatic overrida monitor

DOORS Interlocks for closed position

OPERATING COSTS*

Oct 1, 1980 - Sept 30, 1981

	1981 Dollars	Per Train Mile (478,313 Miles)	Per Passenger Mile (40,660,000 Miles)
MAINTENANCE	$ 1,434,000	$ 3 00	$ 03
OPERATIONAL	1 583,000	3 31	04
ENERGY	330,000	.69	01
TOTAL O. & M	$ 3,347,000	$ 7.00 PTM	$ .09 PPM

* These are 1981 operating costs experienced at the WALT DISNEY WORLD Resort Complex and due to numerous variables (labor rates, electric rates, passenger densities etc.) they may vary significantly in different applications